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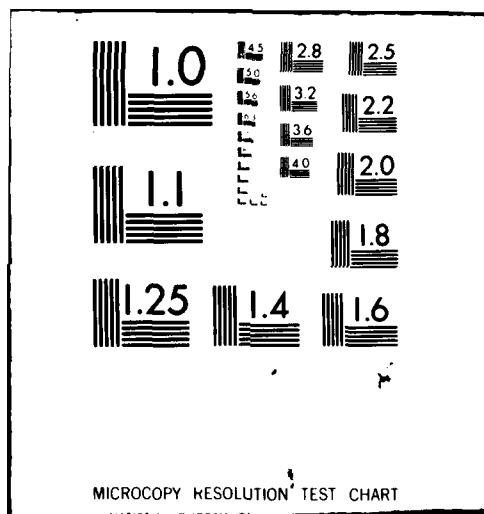
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Third Meeting of the High  
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Scientific Advisory Committee  
January 23-25, 1960

Office of Environment  
and Energy  
Washington, D.C. 20591

Executive Summary

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16. Abstract <p>This is the Executive Summary of the third meeting of the High Altitude Pollution Program Scientific Advisory Committee, which met in Washington, D.C., January 23-25, 1980. The primary focus of the meeting was to assess the applicability and reliability of two-dimensional atmospheric models of the effects of aircraft pollutants on the environment. This is a summary of the Committee's presentation of findings to Mr. Quentin Taylor, Deputy Administrator of the Federal Aviation Administration. Part I is the Chairman's presentation and Part II is the Rapporteur's Summary made just prior to the Chairman's Presentation.</p> <p>The three appendixes are:</p> <ul style="list-style-type: none"><li>I - Agenda</li><li>II - Attendees</li><li>III - Committee Charter and Members</li></ul>		
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THIRD MEETING  
OF THE  
HIGH ALTITUDE POLLUTION PROGRAM  
SCIENTIFIC ADVISORY COMMITTEE

January 23 - 25, 1980

Washington, D.C.

## EXECUTIVE SUMMARY

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### BACKGROUND

The High Altitude Pollution Program (HAPP) Scientific Advisory Committee held its third meeting January 23-25, 1980, at the Federal Aviation Administration (FAA) Headquarters, Washington, D.C. The intended focus of the meeting was a review of the status of two-dimensional models. Specific questions to be addressed were:

- (a) Are 2D models needed to make realistic assessments of the aircraft problem?
- (b) If so, what further improvements, if any, are needed?
- (c) Can the 2D models be verified with available data? If so, how well?
- (d) What additional data are needed to verify or improve these models if available data are inadequate?
- (e) What are the estimated uncertainties in the model calculations?

A complete agenda of scheduled presentations during the meeting is enclosed as Appendix I. The attendees are listed in Appendix II and the Committee Charter and Members are in Appendix III.

The following summary is composed of two parts: the final verbal presentation of the Committee Chairman to Mr. Quentin Taylor, Deputy Administrator of the Federal Aviation Administration; and the Rapporteur's summary to the Committee which was made just prior to the Chairman's presentation. Both parts are taken directly from the transcript of the Committee proceedings, except for editorial changes made for ease of reading. A complete copy of the transcript may be reviewed at the office of the High Altitude Pollution Program (AEE-300), Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, D.C., Telephone (202) 755-8933.

PART I

CHAIRMAN'S PRESENTATION

OF THE FINDINGS

OF THE MEETING

TO THE

DEPUTY ADMINISTRATOR

QUENTIN S. TAYLOR



## PART I. CHAIRMAN'S PRESENTATION

JANUARY 25, 1980

CHAIRMAN ROWLAND: Can we come to order, please? We are pleased to have with us Quentin Taylor, Deputy Administrator of the FAA, and James Densmore from the Office of Environment and Energy.

We are going to report to you our general perceptions of the various possible pollution problems resulting from the operation of aircraft at high altitudes. The report will start with a brief monologue by the Chairman, to be interrupted or disagreed with by the other members of the committee.

### STATUS OF AIRCRAFT EFFECTS IN THE STRATOSPHERE

As we see the overall aircraft problem, there has been a change during the time that HAPP has been in operation. The initial motivation that led to the formation of the committee and the program was the question of whether or not aircraft, operated at the 17 to 20 kilometer level characteristic of SSTs, would have an effect on the quality of the stratospheric environment. In particular, there was an important question of whether there would be an effect on the amount or distribution of ozone in the stratosphere. At the beginning of the program in 1975, the indications were that extensive use of aircraft in the 17-20 km altitude region would result in a diminution in the amount of stratospheric ozone.

During the time that the HAPP program has been in operation, there have been some real developments along that line. In particular, the measurement somewhat more than two years ago of a new, much higher value for one chemical rate constant has shifted the general perception of the effect of the  $\text{NO}_x$  effluents from aircraft at the 17 to 20 kilometer level. As of 1975 or 1976, it was believed that the effect of those  $\text{NO}_x$  effluents would cause a depletion in stratospheric ozone. With the change in the rate constant for the reaction of  $\text{HO}_2$  with  $\text{NO}$  found in 1977, there is now general agreement among the atmospheric models that the injection of  $\text{NO}_x$  at these altitudes would lead to a small increase in the amount of ozone in the stratosphere.

At the same time, it also comes out of the present atmospheric models that the injection of  $\text{NO}_x$  from subsonic aircraft flying at 10 to 12 kilometers will also have an effect on ozone. The indications are that the present subsonic aircraft fleet may have caused an increase in ozone. It is not necessarily a trivial increase, and some of the calculations indicate that it might be as large as a few percent of the total ozone concentration. We will certainly want to come back to discuss this point later.

In terms of the overall concern with the stratospheric problems, we can report that a lot of measurements are in progress through the programs of several agencies, including FAA. I think that there is a good possibility that by 1983, the conclusion date set for HAPP, the scientific community will be in reasonable agreement on the potential effects on stratospheric ozone which can result from the operation of high-flying aircraft.

There are some atmospheric measurements that are definitely needed. Measurement of the concentration of the hydroxyl radical between 20 and 30 kilometers altitude is rather critical to the assessment of the potential effects of aircraft. This is an altitude region in which it has been difficult to make measurements so far. There is, I think, a reasonable possibility that in the next two or three years there will be some satisfactory resolution of that particular experimental problem. There are, in addition, some questions about the reproducibility and general coverage of the measurements of the nitrogen oxides in the 20 to 30 kilometer level. There is some possibility that this problem will also be resolved by the end of the HAPP program. If they are, then I think that the modeling community and the atmospheric science community will probably have very much greater confidence in their description of atmospheric problems in the 20 to 30 kilometer level than they do now.

At the present time, then, the injections of  $\text{NO}_x$  at supersonic aircraft altitudes are certainly not thought to decrease the amount of ozone in the stratosphere. They are instead thought to cause small increases in ozone, and that conclusion is reasonably firm, although there are some experimental measurements that we might expect in the next couple of years that will provide better answers, and much more confidence in the answers that are obtained at that time.

#### STATUS OF AIRCRAFT EFFECTS IN THE TROPOSPHERE

At the same time, all of these recent atmospheric model calculations have now been showing an increase in ozone coming from the operation of subsonic aircraft, not only in the future but also in the past. This has led to several other kinds of questions for which the program was not originally designed, and for which we will probably not have satisfactory answers by 1983. As soon as you start calculating increases in ozone in the troposphere, you find several possible new problems to consider.

One of them is connected simply with the total column of ozone. If you are worried about the penetration of ultraviolet radiation to the ground, and the possible effects of this ultraviolet radiation on the biosphere at the ground level, then your concerns are primarily a matter of how much ozone there is between the ground and the top of the atmosphere. Increases or decreases in ozone concentration at any altitude contribute to the changes in the total amount of ozone in the whole atmospheric column.

However, as soon as you start considering ozone increases in the troposphere itself, then you have potential questions of air quality--whether there might be an increase in ozone concentrations at the surface itself. You also need to consider that increased ozone in the troposphere can contribute to the greenhouse effect--the warming of the atmosphere usually discussed in connection with the observed increases in atmospheric CO<sub>2</sub> concentrations.

One of the major difficulties that we are getting into here is simply that the atmospheric models now in use have been primarily designed to simulate or mimic behavior in the stratosphere, and have had, at least initially, relatively simple descriptions of what happens in the troposphere. If you start asking serious, detailed questions about the troposphere, then you have to reexamine the adequacy of these stratospherically-oriented models in their simulations of the troposphere. We are finding definite gaps in our abilities, both as experimenters in providing data for the modelers, and as modelers in trying to mimic reality. For instance, we have very limited data on the removal from the atmosphere of water-soluble gases such as the nitrogen oxides by the processes of rainout and washout.

We simply do not have much data on the processes by which precipitation removes chemical compounds from the air, and therefore must carry out the modeling in a relatively simple way, reflecting the state of knowledge of the subject. These rainout processes are relatively unimportant for calculations affecting gases 30 or 40 kilometers higher in the atmosphere, but they are very important for accurate simulation of the concentrations of gases in the troposphere.

Thus, to the extent that our understanding suggests that the operation of subsonic aircraft might have important pollution problems associated, our need for good descriptions of tropospheric rainout/washout have greatly increased. Our chances for obtaining both good experimental data and good models for these tropospheric problems by 1983 are not very high.

These tropospheric concerns represent a new aspect. Some of the experiments designed for the stratosphere overlap with these problems, but the troposphere has not been the prime focus for concern. The need for more and better tropospheric data is something that has emerged during the time period that the HAPP Committee has been in operation, and it raises an additional problem about which we think FAA certainly needs and wishes to be informed.

Now, I will ask the rapporteur, Ralph Cicerone, if there is anything which you think I should put in at this point.

DR. CICERONE: No.

CHAIRMAN ROWLAND: Are there any questions you would like to raise at this point to the Committee or to me?

MR. TAYLOR: I don't have any yet. I am more interested in your disagreement or divergences of opinion. Jim (Densmore) may, though.

MR. DENSMORE: No, I agree with you.

#### STATUS OF TWO-DIMENSIONAL MODELS

CHAIRMAN ROWLAND: We have focused our discussions in the last two days on the question of how well we can model the atmosphere. The procedure by which one models the atmosphere is usually broken down into the categories of 1-D, 2-D, and 3-D models. In a 1-D model, the only consideration is variation in the vertical dimension. We average over all longitudes and all latitudes to get some kind of world average.

With the 2-D model, you put in the variation with latitude. With the 3-D model you also add in the variation with longitude. Each new variable that you put into a model costs an enormous amount in computer time and money, and therefore, as you put in the new variable, you are forced to drop out something. In general, the 1-D models have the most complete chemistry and the 3-D models have the most complete meteorology.

Complete 3-D models with full chemistry and full meteorology are far beyond current computer capabilities. This means that simplifying approximations have to be introduced. In effect, everyone has to cheat in some way in order to keep down the magnitude of the computer complexity, and the successful atmospheric modelers are those who find the best simple approximations to some complex set of atmospheric interactions. In this way, many of the 3-D models, while most complete in the meteorology, have very little chemistry in them.

On the other hand, the 1-D models compress all of the meteorology into a simple description which never satisfies a meteorologist, but which does allow computation with complete chemistry included of the vertical distribution of some of these chemical species. The 2-D models become especially important for the aircraft problem simply because the aircraft fly mostly in the northern hemisphere, and mostly in the temperate ozone within the north. We can, therefore, expect appreciable variations in the chemical concentrations of aircraft effluents for different latitudes within the northern hemisphere.

The 2-D models that were shown and discussed here indicate that almost all of the air quality problems from aircraft operation are confined almost entirely to the northern hemisphere. The nitrogen oxides injected into the atmosphere by subsonic aircraft are released at low enough altitudes that relatively little penetrates into the southern hemisphere. This observation is simply not possible with a 1-D model which doesn't consider variations with latitude. With the 2-D model, we can obtain indications of the latitudes at which these effects will occur. The models have shown that the tropospheric effects of nitrogen oxides from aircraft are almost exclusively confined to the northern hemisphere.

MR. TAYLOR: I have a philosophical question with respect to 1-D versus 2-D, and I suppose the general question or proposition is this: Can one proceed in the direction of the development of a 2-D model without at the same time pursuing a 3-D model in the first instance with any real degree of confidence in the findings of the 2-D model?

CHAIRMAN ROWLAND: Basically every time you have a model that is reasonably satisfactory in one dimension, then you want to add one more dimension to make sure that the simpler description is still valid.

In the present situation, the 2-D modelers are leaning fairly heavily on some of the information from Jerry Mahlman and Ed Danielsen, who are coming from the meteorological point of view with sophisticated 3-D models. The 2-D modelers are trying to take segments of information from their own models and make sure that they are consistent with what the 3-D modelers are finding.

Jerry Mahlman said in our discussions that he could put the chemistry into his 3-D model right now, but would not do it until we have gotten all of the bugs out of the chemistry, and are quite happy with it. The 3-D model is too expensive to run unless you have settled what you think the chemistry is.

These 1-D and 2-D models serve very nicely to isolate where and under what conditions you would like to have measurements in the real atmosphere. For example, we find that we would like to know what the ratios are of nitrogen oxide to nitrogen dioxide at different altitudes and latitudes. Once you have figured out what problems are important, and have carried out the necessary validating experiments, then you can say, "I think that the chemistry is in good shape." At that time, you can then put the chemistry into the more complicated models.

From our deliberations, I would say that the main effects which we believe to be occurring from the operation of aircraft at high altitudes are connected with the injection of nitrogen oxides into the atmosphere. This means that the prime concern of the FAA for measurements in the atmosphere has been directed toward measurement and understanding of the nitrogen chemistry.

The program of field measurements is leading to a laser diode technique which hopefully will be able to carry out simultaneous measurements of NO, NO<sub>2</sub>, and nitric acid. Simultaneity of measurement is very important in tests of our understanding of the atmosphere. If you have a report of nitrogen oxide by one technique 100 or 1000 miles and three months away from a measurement of nitric acid, then you just aren't sure how to relate these two. But, if you can do them simultaneously in one air parcel, you have a better understanding of the nitrogen chemistry.

The field measurements program has brought along this laser diode technique. It looks promising, and may be able to be used during the next year or two. Certainly there is a good chance that this technique will produce results by 1983.

The laboratory measurements are also proceeding to pick off some of the real uncertainties which occur there. We did not emphasize laboratory measurements at this meeting, but there were several reports of progress that has been made, including some measurements that are reasonably critical to a detailed understanding in the atmospheric chemistry models.

#### DISCUSSION

MR. TAYLOR: You must be a very, very strong chairman, I notice no dissent at all.

CHAIRMAN ROWLAND: Now we open the meeting up for dissent, Barrie (Pittock)?

DR. PITTOCK: It might be worth saying, too, that with a new focus on the upper troposphere that not only is the modeling effort and the chemistry not being adequately addressed to that problem, but we have also got a particular problem with measurements. Because it is very variable and meteorologically active, in terms of some of the critical chemical species, we perhaps haven't obtained an adequate sample, a long series of observations to see whether there is already an increase in ozone taking place. We did discuss the possibility of perhaps increasing the measurement program in this area.

MR. TAYLOR: I see.

DR. MAHLMAN: Just one mild dissenting vote. Dr. Robinson pointed out that one of the problems that we tend to put our heads in the sand over is the question of water vapor and/or particle emissions in the upper troposphere and its effect on cloudiness. Scientists have

a bias in that they like to discuss problems in which they are confident and in which they are interested. I think we possibly may have swept that under the rug.

It may be because our collective confidence is not strong in that area, but we have not quantitatively established that this is a problem which can be safely ignored.

DR. ROBINSON: There is another measurement problem that we know very little about -- water vapor in the upper troposphere. There has been really no observation.

DR. MAHLMAN: That is very critical because the OH question depends to a large degree on the water that is there.

CHAIRMAN ROWLAND: They were so talkative at 9:30. Paul (Crutzen).

DR. CRUTZEN: I just would like to add that things are changing all the time. The effect of nitrogen oxide emissions at the present are believed to add to the total ozone, but we aren't totally certain of that. There are some disagreements in the measurements both among each other and with the model calculations we should take this not as a too confident statement.

So don't be surprised if maybe in two or three years from now we say, hey, the initial estimates of decreases in ozone actually are closer to the truth than we believed. We are working in an area where there are still uncertainties, and I think by 1983, I am hopeful that we have come closer.

I think we have identified the problems. We know roughly what measurements we have to make to settle them -- both laboratory measurements and measurements in the atmosphere. The question is can we do all those measurements.

CHAIRMAN ROWLAND: The question of trying to establish the degree of uncertainty that you attach to a particular number is one that has been faced in the one-dimensional models for the stratospheric problem, and some answers have been given. When they do these one-dimensional model calculations of the effects of increasing release of chlorine compounds, then the spread in values that you get around a 16 percent estimated loss put a two sigma on either side that ranges from about 5 percent to 28 percent.

If you take the same model and apply it briefly to the NO<sub>x</sub> problem for which everybody would say it is not as likely to be as good, you have, say, a three percent increase, but the two sigma spread includes zero. That says that it is going to be difficult and will require a lot of work in the next couple of years to try to improve that. We will want to see whether or not we can eliminate zero or narrow the distribution, and try to locate the center of the distribution better.

But the model that has been used for these calculations is not very good for the troposphere where many of the effects are being located. A lot of tropospheric work is going to be necessary in order to have this group be happy with any prediction of the overall effects of aircraft emissions on ozone concentrations.

DR. CICERONE: I was going to make a non-technical point. The administrators have heard about all these problems. I think it is good to remind them that FAA is not alone in tackling these related problems.

There is a lot of fire power available from other agencies and indeed from other countries. I think Mr. Broderick and Dr. Sundararaman have helped by convening a committee like this.

We take these arguments back to our places of research and try to focus on these uncertainties because many of them are scientifically interesting in addition to the responsibility we feel towards HAPP.

We have tried to identify those problems where the other agencies and other countries perhaps are not making the progress that is necessary to get the answers that you people are responsible for. The original plans of HAPP are looking pretty good here.

The key uncertainties are being investigated. We don't know yet whether the answers will be defined clearly enough for your purposes by 1983. But you are not alone.

DR. DANIELSEN: Two points. One to amplify something that Sherwood (Rowland) said. Adding the tropospheric component to the problem adds a microphysical problem in addition to a chemical and a transport problem. That is not simply rainout and washout. These cumulonimbus clouds can take water particles and move them all the way up to the upper troposphere and lower stratosphere so that problem also has to be included.

There is a great deal of complexity to it. The other thing is I think that there is now a very strong effort being made by many different groups to instrument aircraft with new sensors for making horizontal measurements of the water vapor and the ozone and various chemical species, and so that we are now, I think, approaching a time when we no longer have to rely entirely on balloon ascents for vertical profiles. We will be supplementing those vertical profiles with horizontal traverses and can get a better understanding of the perturbation. I think there is a new dimension being added and that is the horizontal.

CHAIRMAN ROWLAND: One comment that occurs to me that I didn't bring out, and that is that increasingly the problems of atmospheric pollution are being seen as being multiple problems which interact with one another. The injections of the nitrogen oxide from the aircraft, coupled with injections of carbon dioxide from Burning Fossil Fuels, coupled with injections of chlorine from anthropogenic compounds, all mix together and interact with each other. The models



are having to be increasingly complex in order to make sure that they have the coupling of the various problems put together.

We want now and have asked for the FAA people to try to provide an estimate of the rate of growth of the aircraft fleet over the last 20 years or so. The people who are doing the modeling can then put into their models this increase in aircraft emissions, along with the fluorocarbon production increase and the measured growth of CO<sub>2</sub>.

All of these things are going on simultaneously, and the modelers are shooting at a target that is moving all the time.

MR. TAYLOR: I would like to offer again a non-technical response to the issue itself, I suppose, of air pollution. I suppose it is quite obvious to you that the Federal Aviation Administration will have to remain interested in the effects of various events that would have impact on the atmosphere, and the troposphere, and the stratosphere, and so on.

I wanted to say simply that we are very, very deeply appreciative of your continuing interest in this, and certainly appreciative of your individual as well as your organizational pursuits.

I quite agree with you that we are not alone and we do appreciate that. Even though we don't really know what our atmospheric or tropospheric or stratospheric future might be, we will be called on to respond to those particular challenges and demands.

Simply said, we are going to need other governmental organizations here in the United States to provide data, extractions of data, using systems they have in place. Also, we are going to have to use foreign study entities, that is, foreign scientists, and persons who are interested in this particular endeavor. I have the feeling that because of all of that, it will be very, very necessary for the Federal Aviation Administration and the Department of Transportation to remain a rather forceful catalyst in the study and examination efforts.

I don't at the moment have any ideas as to what the fiscal or monetary situation will look like beyond 1983, but I can tell you this: the level of energy, at least as provided by the FAA, should not diminish. We may have to develop different forms of providing that same energy, but nevertheless, the energy itself will not diminish.

One general question I would ask is this: beyond 1983, presuming now that I have a reasonably firm grasp of what it is you will be engaged in up until 1983, what do you imagine might be the scientific pursuits that we collectively would be engaged in beyond '83?

CHAIRMAN ROWLAND: I think that the general reaction of the atmospheric science community has been that because of the SST problem as raised in the early seventies, there was suddenly a very

large interest and investigation of the stratosphere. As people have looked for more and more information there, the lack of knowledge of what is happening just below it has struck more and more people. The emphasis of a lot of agencies has been to say the stratosphere in a lot of ways is a lot simpler than the troposphere. I think the scientists are starting to look down into the troposphere and find that there are some interesting scientific problems there. At the same time, they are finding out that there are some environmental problems or at least environmental concerns arising from them. So I think a lot of the people are going to go down in altitude and be looking at what happens in the troposphere, at the chemistry, or meteorology, or the modeling. Almost everybody is settling down in altitude in their thinking.

MR. TAYLOR: That will be an interesting area to settle down to, if for only one reason, and that reason would be on energy sources. It seems to me that substitute energy sources of one kind or another are going to come in place simply because they must.

One could apply that certainly to aviation. Who knows, for instance, when we would have a hydrogen-propelled aircraft. It probably will come. More than that, when you consider ground sources of emittance into the air, what really happens if we are forced in the direction of coal? What really happens if we don't use coal at all and at the same time use less in the way of petroleum energy sources and move in the nuclear direction.

There are just thousands of questions, I am sure, that might be asked simply about our energy future, and at the same time, those same questions might apply themselves to the lower levels, the troposphere.

So it ought to be interesting. That is, developing the adequate measurement techniques such as to determine not only what will happen, but what is happening as we change in terms of energy utilization.

DR. SCHMELTEKOPF: To answer one of your earlier questions, I think we are not capable of making a prediction of what we will be doing in three years, because what we will be doing in three years is so dependent on one of two things, accident or a new idea.

If you look back at our history, you will find that the whole community sort of turns like a bunch of geese in flight when some guy thinks of a new idea or makes a measurement that everybody thought was stupid to be doing again, but found out something new.

There is no possibility of predicting what is going to happen there, but I will bet you in the next three years there will be at least one of those.

MR. TAYLOR: Sure. Either a new measurement or an observation or a major error.

DR. SCHMELTEKOPF: That is right.

MR. TAYLOR: And that will turn the geese certainly.

CHAIRMAN ROWLAND: Are there any other comments that anyone would like to make to the Deputy Administrator at this point?

(PAUSE)

I think we have presented to you a reasonable description of where we stand. I am not aware that there is any reason why the committee needs to meet separately afterward.

If no one raises a question at this point, I think this is an appropriate time to conclude the report and adjourn the meeting.

MR. DENSMORE: I would like to ask kind of a judgmental question that may not be a very answerable one. We can sort of trace the Committee's actions amny other people's in looking at the stratosphere, and now we are concluding that there is some concern in the troposphere. Can you draw any kind of parallel as to how far we are in troposphere considerations?

Where are we in getting a corral around the matter and being able to put some boundaries on it and more focused efforts and trying to get at some conclusions we would like to get in the troposphere?

CHAIRMAN ROWLAND: That is difficult. Crudely, we are five or six years behind, I would say something like that.

DR. SCHMELTEKOPF: There are a lot of areas of uneasiness in the troposphere that we don't have in the stratosphere -- this rainout, washout business.

MR. DENSMORE: There is a lot more measurement in the troposphere, but they may not do us much good on this issue. It is a much different situtation.

CHAIRMAN ROWLAND: There is so much variability. the enormous variability makes it much more important to have simultaneous measurements to know what went on in a particular parcel at a particular time. In the upper stratosphere there is a reasonable presumption that if you go back the next day, it will look somewhat the same as yesterday.

We know that is not true in the troposphere. You can't go back the next day and get the measurements. You have to do it all at once. The stratosphere people want to do it in the same day too, but it is much more important in the troposphere.

DR. CICERONE: We are poorly equipped in tropospheric chemistry at this point for several reasons, coverage in the measurements and a knowledge of what has been done. It is so polluted that it is difficult to understand how the system worked before this so it is difficult to understand the change.

We need more work in the southern hemisphere on the key questions. We can't afford to measure everything in the southern hemisphere. We have been finding that the troposphere is not just one big box, but there are distinctly different regimes.

In the marine boundary layer where much of the action is taking place in the removal of pollutants, the measurements have been surprising in the last couple of years. The chemicals being found there and the concentrations are different from what we expected and different from what we call the free troposphere above the boundary layer.

We thought we could do simple averaging over the entire troposphere and now we are finding there is more structure there. There are programs in place. Although moving a little peripatetically, they are moving.

There have been major shocks of the kind you gentlemen described and we are digesting those and making refinements now.

DR. SCHMELTEKOPF: Odd nitrogen chemistry doesn't seem to close on itself if you compare the measurements and the modeling. There seems to be a sort of a gap there that has a possibility of being important.

That makes me very uneasy, and I would very much expect that gap would be closed by '83. If so, I think that will at least make many people feel more confident if it were closed.

CHAIRMAN ROWLAND: Barrie (Pittock)?

DR. PITTOCK: I should take up Ralph's (Cicerone) ...

DR. CICERONE: He is from Australia.

DR. PITTOCK: Just to point out that there has been a fair input from Australia on southern hemisphere measurements, but I think at the moment we are in a hard place in terms of the economic situation, and I firmly believe in principle that Australia should be doing its own scientific work and not asking for help, but there are some things that I think are necessary measurements from the American point of view which have been in jeopardy because of the financial considerations in Australia.

I think it may be that there needs to be very firm statements of necessity for those measurements to be made, which might be a useful lever.

CHAIRMAN ROWLAND: If there are no other comments and no questions, then I think we can adjourn at this point.

MR. TAYLOR: Gentlemen, thank you.

(Whereupon, at 11:15 a.m. the meeting was concluded.)

PART II

RAPPORTEUR'S SUMMARY

Rapporteur: Dr. Ralph Cicerone

## PART II: RAPPORTEUR'S SUMMARY

CHAIRMAN ROWLAND: I think we will go to Ralph Cicerone (the rapporteur) for a summary of what has happened so far in this meeting.

DR. CICERONE: I have simply tried to follow the format of the letter we received, the "Dear Colleague" letter, which listed five questions that were to be addressed at this meeting.

If any of you have a copy of the letter it might make it easier to follow the way I have tried to prepare a summary of what we have said.

What I plan to do, just to give you a brief outline, is to read those questions once again and then to list the items that I think were agreed upon, the replies to those questions and the items that need work. As always, this is just one person's attempt to summarize, so we will appreciate all your modifications.

The first question was are 2-D models needed for assessing aircraft effects on atmospheric ozone, actually the entire aircraft problem. I think our answer was "yes" because of the nature of 1-D models and the limited prospects for 3-D models with chemistry to be tested for 1983.

We go on then to needed improvements. I have simply listed the improvements that are needed. The next two categories are those improvements, verifications and tests, which can be accomplished with available data as opposed to those which require new data for improvements, verification or testing or all three.

Finally, I will try to mention a couple of loose ends that I think we overlooked yesterday.

One needed improvement that was identified here again was the need to place 2-D models that contain diffusive fluxes on a more solid physical footing at least by using only self-consistent mean motions and diffusion coefficients of the type that several people described. The diffusion coefficients could be derived after the mean motions were established in another way and done self-consistently.

DR. CRUTZEN: I hope it will work because I am very skeptical. I think self-consistency is a little over-ambitious there. We should not forget that an engineering approach is maybe not too bad an idea.

DR. CICERONE: I list that later in the tests that can be accomplished with available data, simply by taking all the new chemical tracer data and trying to work harder at the engineering approach to achieve agreement with all available tracer data.

DR. CRUTZEN: This includes the possibility, I think, that the self-consistent diffusion and mean motions which are derived, once you put it in a chemical model, give you a total ozone distribution which is 180 degrees-out-of-phase.

That is what happened with the previous set we used. I am very skeptical of this approach.

DR. MAHLMAN: I think Paul (Crutzen) has a valid point that is worthy of consideration in the sense that we have this uneasy feeling that empirical or two-dimensional models lack a firm conceptual basis for making predictions. However, that is an unproven concern.

On the other hand, we scientifically would wish to have a more valid conceptual basis for two-dimensional models, whatever that is. Certainly all of the possibilities have not been covered during this meeting and I think it is appropriate to ask for continued work toward making more conceptually correct two-dimensional models.

It seems like a balanced statement of this kind would be in order.

DR. CICERONE: Very good. Let me go on then.

Other examples of needed improvement would be: the inclusion of temperature and dynamic feedback effects of chemical perturbation in some 2-D models; to refine the chemical reaction schemes in some 2-D models to equal those now in 1-D models, to make sure that the available, pertinent chemistry is included; and to enlarge the spatial grid, to include the troposphere with enough resolution to calculate tropospheric ozone and key species well enough to compare with available and future data. I think we saw that the spatial grid (used in the 2-D models) and the amount of effort that has gone into tropospheric chemistry is inadequate to make these comparisons at this time.

With refinements to the tropospheric chemical scheme, the aircraft injection calculations need to be repeated to see if the calculated patterns found so far in present 2-D and 1-D models persist with those refinements. I think we also agreed on the need to assess uncertainties in 2-D calculations, but with no specific recommendations on how to do it.

The next question and topic was tests and verifications that can be performed with available data. The first is to evaluate the 2-D model capabilities in dispersing aircraft emissions by first of all running the available models with standard nitric oxide injection patterns.



Second, performing tracer studies for aircraft emissions both in the upper troposphere and in the lower stratosphere with 3-D GCMs\* as feasible and to use the results to define the 2-D parameterizations as much as possible. The third one that I just mentioned, is to refine the empirical transport coefficients in the 2-D models with available chemical tracer data such as nitrous oxide, water vapor, methane and fluorocarbon measurements.

What additional data are needed to test and improve 2-D models? I think we agreed on the following: simultaneous and possibly redundant measurements of NO, NO<sub>2</sub>, HNO<sub>3</sub>, and total odd nitrogen in the lower to mid-stratosphere where we are seeing ratios of NO<sub>2</sub> and HNO<sub>3</sub> that do not agree with present models.

DR. SCHIFF: I am not sure I understand what redundant means.

DR. CICERONE: Art Schmeltekopf's point and your point yesterday, meaning more than one instrument measuring the same item, the same species.

DR. SCHIFF: I think perhaps that is so important that it ought to be spelled out specifically as more than one technique. I feel sufficiently strongly about it. I would like to see that spelled out specifically, define the word "redundant" as "by more than one technique."

DR. SCHMELTEKOPF: I think that is important, too. There is no point in having two semi-identical instruments measuring the same thing.

DR. SCHIFF: If we both measure at the same time and same place I don't think that is terribly meaningful. They won't agree --

DR. CRUTZEN: That is why it is not meaningful.

DR. CICERONE: By independent techniques as far as possible and to include hydroxyl as far as possible, but recognizing that the measurement has not been made by anybody yet.

DR. SCHMELTEKOPF: I don't think your list had ozone in it.

DR. CICERONE: In the lower to mid-stratosphere Art (Schmeltekopf) is right.

DR. SCHMELTEKOPF: You ought to put that in there if you put in the others. If you are going to talk about the chemicals and make a list it ought to have ozone in it.

DR. CICERONE: The next item was upper stratospheric NO. Because of the possibility that previous measurements were low and the indications from one recent measurement and the continuing need to have a measure of total odd nitrogen in the stratosphere, I think we still need measurements of upper stratospheric nitric oxide.

\*General Circulation Models.

The third category, which was still not made very specific, is additional data needed to test and improve 2-D models. Active tracer experiments, for example, the release of an artificial tracer in a flight corridor with subsequent sampling at appropriate temporal and spatial resolution. For other reasons, the desirable artificial tracer would be water soluble.

Upper tropospheric nitrogen oxides. Again, recognizing that these measurements are very difficult and have only been done on a spot basis, if at all, so we can't ask for everything.

Laboratory or atmospheric measurements on precipitation removal of trace gases, especially the nitrogen oxides and  $\text{HNO}_3$  to include solid phase scavenging of trace gases.

The final item is something I added...further calculations to be done using available models and new ones when they become available. One is the possibility -- I don't think we realized this yesterday with the calculations we saw from George Widhopf, Paul Crutzen and Lou Gidel, the ozone increases in the vicinity of the low latitude tropopause were of an order of ten percent, possibly fifteen. You may call it then effects modeling. Focusing a bit more attention on the effects that we are already calculating, for example, what would be the thermal effects of those ozone increases in the vicinity of the low latitude tropopause with possible water vapor fluxes into the stratosphere?

Two last points that, from what we heard of the field measurements program and progress, it is already focused on several of our recommendations and we just hope that progress in the diode laser field will lead to these measurements. Also with the lab experiments, especially what Dr. Smith described in the methane chain products and - intermediate reaction rates, they appear to be as important as we originally thought, so progress there looks encouraging. That is everything I have included. That is it.

CHAIRMAN ROWLAND: Bob? (Oliver)

DR. OLIVER: One of the things that was mentioned which I think is probably not really part of your problem. We would like to get a reasonable estimate of  $\text{NO}_x$  injections from current aircraft. We have the 1990 stuff which is pie in the sky, but I don't think we have reasonable current estimates.

CHAIRMAN ROWLAND: I think more than just current, we would like to have the time line for it.

DR. OLIVER: If possible, yes.

DR. SCHMELTEKOPF: I would like to hear some discussion on whether we really have any agreement on whether we wanted to recommend injection experiments. I thought we talked about that a little bit, but I didn't get the feeling that we were going to recommend it very highly.

CHAIRMAN ROWLAND: Ralph (Cicerone), would you repeat what you said about an injection experiment?

DR. CICERONE: This is under the category of additional data needed. We haven't recommended measurements. We just recognized that those data are probably needed.

APPENDIX I

AGENDA

HIGH ALTITUDE POLLUTION PROGRAM

SCIENTIFIC ADVISORY COMMITTEE

THIRD MEETING

JANUARY 23 - 25, 1980

THIRD MEETING  
HIGH ALTITUDE POLLUTION PROGRAM  
SCIENTIFIC ADVISORY COMMITTEE

AGENDA

January 23, 1980: Wednesday

10:00 <u>A.M.</u>	Call to Order.
	Opening remarks by the Chairman - F. S. Rowland
10:15	Introductory remarks by Manager, HAPP - N. Sundararaman
10:20	Progress Report on the Laboratory Program: W. Smith.
10:35	Progress Report on Rainout/Washout Studies: S. Schwartz, Brookhaven National Laboratory
10:50	Break
11:00	Aerospace 2D Model: G. Widhopf/L. Glatt, Aerospace Corporation
12:30 <u>P.M.</u>	Adjourn for Lunch
1:30	Aerospace 2D Model: (Cont'd)
3:00	Uncertainty Studies: R. Stolarski, NASA/Goddard
3:30	Break
3:45	Crutzen 2D Model: P. Crutzen/L. Gidel, NCAR Colorado State University.
5:00	Adjourn

January 24, 1980: Thursday

9:00 <u>A.M.</u>	Crutzen 2 D Model: (Cont'd).
10:15	Break
10:30	Stratospheric - Tropospheric Exchange Process: E. Danielsen, NASA/AMES
12:00 Noon	Adjourn for Lunch

1:00 P.M.                      Stratospheric - Tropospheric Exchange  
   Process: (Cont'd).

2:15                              2D Models: H. Hidalgo, Institute for Defense  
   Analyses

2: 45                              Break

3:00                              Discussion

5:00                              Adjourn

January 25, 1980: Friday

9:00 A.M.                      Summarization by the Rapporteur - R. Cicerone  
   Discussion and Recommendations.

10:15                              Break

10:30                              Presentation of the Recommendations by the  
   Chairman to Q. Taylor, FAA, Deputy Administrator  
   Dates and Agenda items for the next meeting.

12:00 Noon                      Adjourn

(Rapporteur: Dr. Ralph J. Cicerone)

APPENDIX II

ATTENDEES

HIGH ALTITUDE POLLUTION PROGRAM

SCIENTIFIC ADVISORY COMMITTEE

THIRD MEETING

JANUARY 23 - 25, 1980

ATTENDEES  
THIRD MEETING OF  
HIGH ALTITUDE POLLUTION PROGRAM  
SCIENTIFIC ADVISORY COMMITTEE  
JANUARY 23-25, 1980

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APPENDIX III

CHARTER

AND

MEMBERS OF

HIGH ALTITUDE POLLUTION PROGRAM

SCIENTIFIC ADVISORY COMMITTEE

THIRD MEETING

JANUARY 23 - 25, 1980

# ORDER

## DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

1110.83A

4/14/78

### SUBJ: HIGH ALTITUDE POLLUTION PROGRAM SCIENTIFIC ADVISORY COMMITTEE

1. PURPOSE. This order amends the charter of the High Altitude Pollution Program Technical Advisory Committee and changes its name to the HIGH ALTITUDE POLLUTION PROGRAM SCIENTIFIC ADVISORY COMMITTEE.
2. DISTRIBUTION. This order is distributed to division level in Washington and centers and director level in the regions.
3. CANCELLATION. Order 1110.83, High Altitude Pollution Program Technical Advisory Committee, is canceled.
4. BACKGROUND. The Office of Environmental Quality, Federal Aviation Administration (FAA), has established the High Altitude Pollution Program (HAPP) charged with a continuing effort to determine quantitatively the requirements for reduced cruise-altitude exhaust emissions by high altitude aircraft and to determine what regulatory action, if any, is needed to avoid environmental degradation. Accordingly, HAPP must pursue programs related to aircraft engine emissions improvement, aircraft operations, stratospheric measurements, computer modeling of stratospheric processes, laboratory measurements related to stratospheric phenomena, and monitoring of stratospheric phenomena. HAPP has the lead role for the Department of Transportation in carrying out U.S. responsibilities defined in the May 1976 Tripartite Agreement Regarding Monitoring of the Stratosphere, which was signed as a result of one of the actions directed by the Secretary in his February 4, 1976, decision on Concorde. The program must draw upon FAA-sponsored research and on the work of other U.S. and international organizations. It has implications for the aviation manufacturers, airlines, and the general public, both in the United States and internationally. For these reasons, it has been determined necessary to have a HAPP Scientific Advisory Committee to serve the manager of HAPP in assessing and advising on elements of HAPP.
5. OBJECTIVE AND SCOPE OF ACTIVITIES. The objective of the Committee is to review the scope, adequacy, and priorities of HAPP, advise on areas of research that may contribute to the analyses conducted by HAPP, appraise analyses conducted, advise of relevant results in related fields of investigation, and assist in coordinating the relevant programs of other Government agencies with those of HAPP.
6. DESCRIPTION OF DUTIES. The Committee's activity is limited to program review and submission of recommendations and advice to the HAPP program manager.

4/14/78

## 7. ORGANIZATION AND ADMINISTRATION.

\* a. The HAPP Scientific Advisory Committee shall have up to twenty-five \* members consisting of representatives of the aviation industry and scientists and engineers from Government, specifically including, but not limited to, representatives of the Department of Defense, the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration, industry, and universities. Persons chosen for membership on the Committee are selected on the basis of their recognized expertise and ability to contribute significant advice to the FAA in technical areas, such as aircraft engine emissions measurement or improvement; aircraft operations; stratospheric measurements; computer modeling of stratospheric processes; laboratory measurements related to stratospheric phenomena; and monitoring of stratospheric phenomena. Committee participation by non-Government members does not make them special Government employees. The non-Government members shall be selected by the Associate Administrator for Policy Development and Review, with the approval of the Administrator and the Secretary of Transportation, and such members shall be selected so as to be fairly balanced in terms of points of view represented and functions to be performed by the Committee.

\* b. The Administrator is the sponsor of the Committee and shall appoint the chairman. The Director of Environmental Quality is responsible for providing the administrative support for the Committee and shall provide a secretariat. The executive director shall be the FAA's Associate Administrator for Policy Development and Review. The Committee shall not conduct any meeting in the absence of the executive director or the designated alternate. The executive director or the designated alternate, who as the designated Federal employee, shall be authorized to adjourn any advisory committee meeting whenever he determines adjournment to be in the public interest.

\* c. The chairman shall be responsible for: \*

(1) Determining, with approval of the executive director, when a meeting is required.

(2) Formulating an agenda for each meeting, which will be approved in advance by the executive director.

(3) Providing for notice to all members of the time, place, and agenda for any meeting.

(4) Conducting the meeting.

(5) Providing for the taking of minutes at each meeting and certifying the accuracy of the minutes.

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d. The number of meetings is expected to be one, and possibly two, per year.

e. Detailed minutes shall be kept of each Committee meeting. The minutes shall include the time and place of the meeting; a list of Committee members and staff and agency employees present at the meeting; a complete summary of matters discussed and conclusions reached; copies of all reports received, issued, or approved by the Committee; a description of the extent to which the meeting was open to the public; a description of public participation, including a list of members of the public who presented oral or written statements; and an estimate of the number of members of the public who attended the meeting.

f. The Committee meetings shall be open to the public, and timely notice of such meetings shall be published in the Federal Register at least 15 days before the meeting. The proposed agenda, as well as the time and place of the meeting and information that the meeting will be open to the public, shall be included in the notice which shall be forwarded to the Chief Counsel, Attention: Rules Dockets Section, AGC-24, approximately 30 days before the meeting. Other forms of notice, such as press releases, are to be used to the extent practicable.

g. Members of the Committee who are full-time employees of the United States shall serve without compensation but may be allowed transportation and per diem in lieu of subsistence and other expenses, in accordance with the Department of Transportation's Civilian Travel Regulations.

8. ESTIMATED COST. The estimated annual operating cost of the Committee is \$10,000, which includes the travel costs and compensation of the members and miscellaneous costs, such as the printing and issuance of reports. Approximately 0.2 employee-years will be required to support the Committee, including both professional and secretary services.

9. COMPENSATION. Members of the Committee who are not full-time employees of the United States, while attending meetings of the Committee or otherwise engaged in the business of the Committee, shall be entitled to compensation of \$100 per day and transportation and per diem in lieu of subsistence and other expenses in accordance with the Department of Transportation's Civilian Travel Regulations.

10. PUBLIC PARTICIPATION. Each Committee meeting shall be open to the public and interested persons shall be permitted to attend, appear before, or file written statements with the Committee, subject to the limitations contained in the exception to the Freedom of Information Act (Title 5, U.S. Code 552(b)) and also subject to limitations of space and time.

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11. AVAILABILITY OF RECORDS. Subject to the limitations contained in the exceptions of the Freedom of Information Act (Title 5, U.S. Code 552(b)), records, reports, transcripts, minutes, and other documents that are made available to, or prepared for or by, the Committee shall be available for public inspection and copying at the Office of Public Affairs 800 Independence Avenue, S.W., Washington, D.C. 20591. Fees shall be charged for information furnished to the public in accordance with the fee schedule published in Part 7 of Title 49, Code of Federal Regulations.

12. PUBLIC INTEREST. The formation and use of the HAPP Scientific Advisory Committee is determined to be in the public interest in connection with the performance of duties imposed on FAA by law.

13. EFFECTIVE DATE AND DURATION. This charter was filed on June 12, 1978, which is its effective date. The Committee will remain in existence for two years subsequent to this date, unless sooner terminated or extended. (Since HAPP will be in effect for eight years, the Committee will be needed for eight years. Accordingly, the charter will be refiled after the two-year period.)

  
Langhorne Bond  
Administrator

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\*ADDRESSES UPDATED JANUARY 1981



**DATE**  
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